Scarcelli, Berardi, and Shih Reply: First, we thank Gatti *et al.* [1] for the opportunity to further discuss the physics behind the phenomenon. Classical interpretations of the Hanbury Brown–Twiss (HBT) effects, including the one by Gatti *et al.*, have been given for 50 years. We are not satisfied with them and this is why in [2] we have offered an alternative explanation of two-photon correlation phenomena for chaotic light. We are not the first ones in history to put forth this effort [3]. Our contribution has been to derive, for the first time and from first principles, an explicit expression [Eq. (8) of [2]] to show that these two-photon phenomena are the result of a quantum interference between indistinguishable Feynman alternatives. Furthermore, we have presented an experiment to visualize the physics beyond the historical HBT experiment. Our efforts have provided the only interpretation of two-photon phenomena that can be applied consistently to both ''classical'' and ''quantum'' light.

The comment by Gatti *et al.* seems to be inspired by the popular perception of the two-photon phenomenon as the correlation between identical copies of ''speckles'' across two light beams. However, one may simply split a laser beam into two using a beam splitter to observe identical speckles on the two beams and yet, in this situation, the second-order degree of coherence $\gamma^{(2)}(\vec{x}_1, \vec{x}_2)$ is constant. Moreover, Gatti *et al.* applied a multimode integral to derive the position correlation $\delta(\vec{x}_1 - \vec{x}_2)$ of chaotic light; however, there is a contradiction between the multimode picture and the interpretation of intensity fluctuation correlation. The intensity fluctuation correlation is due to the supposed identical fluctuations experienced by the same mode of the radiation, while, as we all agree, for chaotic radiation different modes fluctuate independently. Hence, the intensity fluctuation correlation is observable only when the two detectors receive the same mode; this correlation must be averaged out when the detectors collect a large number of modes. Our design of the lensless ghost imaging system exactly addresses this point by measuring a correlation in the ''near field'' while collecting a large number of modes simultaneously. Interestingly, in the first part of their Comment Gatti *et al.* claim our observation is due to a position correlation; then, in the second part, they claim that the effect is due to a correlation between pairs of modes (momentum correlation). This is paradoxical and against the very nature of chaotic radiation.

Next, let us focus on Eq. (1) of the Comment, which is equivalent to $\Gamma^{(2)}(\vec{x}_1;\vec{x}_2) = \Gamma^{(1)}_{11}(\vec{x}_1)\Gamma^{(1)}_{22}(\vec{x}_2) + |\Gamma^{(1)}_{12}(\vec{x}_1;\vec{x}_2)|^2$, where $\Gamma^{(1)}_{12}$ is the mutual coherence function in classical theory. $\Gamma^{(1)}_{12} = \langle E^*(\vec{x}_1)E(\vec{x}_2)\rangle$ quantifies the first-order coherence between fields E_1 and E_2. Experimentally, $\Gamma^{(1)}_{12}$ is measured by one photodetector at the space-time point where E_1 and E_2 are superposed. In contrast, in this situation, $\Gamma^{(1)}_{12}$ would be measured by two distant, independent, photodetectors at $\vec{x}_1$ and $\vec{x}_2$. The fields are never added at a space-time point. Although $\Gamma^{(2)}$ is formally written in terms of $\Gamma^{(1)}_{12}$, $\Gamma^{(2)}$ is not a measure of the first-order mutual coherence. Thus, the classical mutual coherence explanation is not applicable in this case. Gatti *et al.*, though, do not correctly apply the classical concept of first-order mutual coherence. For them, ''mutual coherence'' means ''mutual phase coherence between pairs of modes (in arms 1 and 2, respectively).'' Hence, the two beams are incoherent on their own but coherent between each other. This is in contradiction with classical theory where the second-order and the first-order degrees of coherence for chaotic light are connected by $\gamma^{(2)} = 1 + |\gamma^{(1)}_{12}|^2$. Using a different perspective, our interpretation resolves this contradiction by picturing the effect as a two-photon interference. In our opinion, it is more acceptable to interpret $g_2(\vec{x}_2, \vec{q})g_1(\vec{x}_1, \vec{q}\,')$ and $g_2(\vec{x}_2, \vec{q}\,')g_1(\vec{x}_1, \vec{q})$ in terms of two-photon amplitudes, corresponding to different yet indistinguishable alternative ways of triggering a joint photoelectron event. In addition, we find it difficult to apply the classical interpretation in the photon counting regime using coincidence circuits while the two-photon interference picture arises naturally from Glauber's theory of photodetection.

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